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The Effect of the Change in Call Loan Rates and Volatility on Stock Returns in 1929: An Empirical Study into a Determinant of the Great Depression

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Abstract

I investigate the effect of the change in call loan rates on stock returns during 1929. Call loan rates are the interest rates on borrowed funds to trade equity on a given exchange. It is estimated that 40% of stocks during this period were bought on margin. After a price decline comes a margin call, followed by a forced sales of securities, which leads to additional margin calls and future price declines. I regress daily excess returns on the change in daily call loan rates during 1929. In addition, I estimate volatility using an ARCH model and observe the previously understood negative relationship between volatility and stock prices. I find a statistically significant negative relationship between call loan rates and stock returns. Furthermore, I also find that changes in call loan rates are most influential on the manufacturing sector relative to the other 11 industries tested.

1. Introduction

A frequently debated hypothesis posits that reducing the percentage of borrowed funds used to finance stock positions (margin requirements). A heavily contested and controversial view, the use of margin requirements to control stock return volatility and returns has been used as the primary rationale behind the Federal Reserve (Fed)'s initial use of the policy. Hardouvelis (1988) sets the precedent for future debate on the subject by finding that historical evidence supports the proposition that margin requirements reduce stock return volatility. This was a widely held view prior to Hardouvelis (1988) but Hardouvelis gained notoriety because he was one of the first to perform an empirical test explaining the validity of this view.

The majority of later papers in the subject including those of Kupiec (1989), Salinger (1989), and Hsieh and Miller (1990) showed through different reasoning that Hardouvelis (1988)'s result was erroneous because of incorrect empirical techniques. The most commonly cited issue was Hardouvelis (1988)'s use of a 12-month moving standard deviation which is only a backward looking measure, not a forward looking one. All of the authors adjusted their own tests by either using different measures for volatility such as the General Autoregressive Conditional Heteroscedasticity (GARCH) or replicating Hardouvelis (1988)'s study for different sample periods. All found that there is no meaningful relationship between margin requirements and volatility or stock returns.

Hardouvelis (1990) accounted for this criticism by adjusting his model to use a different monthly measure for volatility and found the same statistically significant margin-volatility relationship as his 1988 paper. Hsieh and Miller (1990) further criticized this measure by arguing that Hardouvelis (1988, 1990) should have taken differences in variables, not levels. They corrected for this apparent misspecification and found no significant result. Hardouvelis and Theodossiou (2002) disputed Hsieh and Miller (1990)'s criticism by arguing that volatility and margin requirements are stationary and thus taking differences in the variables is incorrect.

In summary, the majority of the previous literature concludes that there is no significant relationship between changing the margin requirement and that change's impact on volatility or stock returns. Although it should be noted that there is considerable reference to Hardouvelis's findings and controversy over the validity of his methodology and results.

This paper takes a step away from the existing debate about margin requirements by focusing on a variable that has been discussed in the literature but only from a theoretical perspective as a perceived influence on stock prices: the call loan rate. The debate on margin requirements and the lack of consensus in the literature is important to discuss for two reasons. The first is that it points to an abundance of discussion about the validity of an important monetary policy. The second is that the debate highlights an apparent lack of discussion on a highly related topic that may have an influence on stock prices. Therefore, the purpose of this paper is to discuss the importance of this variable and empirically test the change in call loan rates' effect on total stock market and industry returns.

Margin trading plays a significant role in financial markets because it gives investors an ability to invest a larger amount in marginable securities than they otherwise would be able to using cash.[1] This is important because many investors use it to boost returns above and beyond what they could have done without the use of margin.

I began my analysis by collecting daily data of call loan rates in 1929. This data lies in the historical section of the New York Times. I chose 1929 for several reasons. The first is that the Great Depression is widely understood as the most significant financial crisis to date and being able to empirically explain the dramatic fall in prices would constitute a significant contribution to the literature. The second is that various metrics indicated that borrowing costs were low during the latter half of 1929 when the market crashed. For example, traditional margin requirements were low during this period, becoming as low as 10%.[2] Broker loan volume was high at a time when money rates were low on October 3rd where the rate dropped to 6% from 7.5% the day before.[3] Furthermore, a large fraction (around 40%) of stocks were being bought on margin.[4] Thirdly, margin requirements were not regulated by the Fed like they are today. Instead, brokers controlled these loans and set the price according to their own interests which likely contributed to the low interest rate associated with borrowing. Brokers profit as the number of loans they give out increases.

Factors explaining the low barrier to trading on credit is important for this topic because the call loan rate is a short term interest rate which was the principal rate brokers borrowed at. This low rate quantified the ease with which shares on margin could be

[1] Randy Frederick, Charles Schwab, February 08, 2018: This percentage generally differs by broker. Modern margin agreements allow for borrowing up to 50% of the purchase price of marginable securities.
[2] 1929: The Great Crash, a BBC documentary, October 29, 2009
[3] Financial times, October 4, 1929
[4] Entangled Political Economy: Roger Koppl, Steven Horowitz, Page 142, October 3, 2014

purchased for brokers' clients. Finally, 1929 is useful because there is ample variation in the call loan rate which is valuable for econometric analyses.

I collected daily stock return data from Ken French's website in addition to returns on Fama and French (1993)'s SMB and HML factors used to explain variation in returns. I also collected returns data on 12 industries. To avoid the problems mentioned by Hsieh and Miller (1990) and others regarding Hardouvelis (1988, 1990)'s measure of volatility, I used an Autoregressive Conditional Heteroscedasticity one lag model [ARCH (1)] to determine daily volatility. Black (1976) and Christie (1982) showed that there is a negative relationship between volatility and stock prices. This occurs because as stock prices fall, the firm becomes more levered due to an inherent adjustment in the percentage of debt in a firm's capital structure.[5] Leverage makes cash flows riskier to equity holders which raises the required return on equity (ROE) and volatility of stock returns. An alternate explanation for Black (1976)'s finding is that high market volatility means that stocks are relatively risky when compared to other riskless instruments like treasury bills and hence demand a higher risk premium. This implies that upward movements in volatility (assuming that volatility is expected to remain high for some time) would lead to lower stock prices and hence negative returns. For these reasons, I expected the coefficient on volatility to be negative and statistically significant for the regression specifications which I ran and which are explained in more detail later in this paper.

I ran six different regression specifications in order to determine the effect of a change in the call loan rate on stock returns. I began by regressing daily returns from 1929

[5] In company financial statements, Debt is denoted in book value, whereas references to capital structure generally assume book value of debt and market value of equity.

on the percentage change in call loan rates. I then included daily volatility as an additional explanatory variable. I also regressed industry excess returns on excess market returns and the change in the call loan rate. I then added in volatility as an explanatory variable. My final two specifications mimic the 3rd and 4th specifications except that they include the Fama-French SMB and HML factors.

I found a statistically significant negative relationship between the change in call loan rates and total stock market returns during 1929. The coefficient on *calldiffpct* in the first specification is -1.653 and the coefficient changes to -1.609 upon the introduction of volatility into the regression. Volatility has a statistically significant coefficient of -0.614. Specifically, a one standard deviation move of 0.18% in the call loan rate difference in percentage results in 0.299% drop in stock returns. When including market volatility as an explanatory variable, I found that a one standard deviation change in call loan rates results in a 0.291% drop in stock returns. A one standard deviation move in the change in volatility as a percentage of roughly 0.6% reduces daily stock returns by 0.37%.

After looking at the broader market, I looked at the effect of the change in call loan rates on 12 different industries in order to understand whether this effect is different across industries. I found that in each industry specification, the only industry with a negative and statistically significant coefficient is manufacturing with a coefficient ranging from -0.362 to -0.450 depending on the specification. A one standard deviation move of 0.18% in the call loan rate with a coefficient of -0.362 when including the market, volatility, and the Fama-French factors results in a 0.065% reduction in daily returns for the manufacturing industry. A one standard deviation change in the volatility of manufacturing returns of

0.6% and a coefficient on volatility of 0.253 increases daily returns by 0.15%. Besides the consistency of manufacturing in providing statistically significant results, the lack of significance of call loan rates and volatility on other industry returns might imply that the effects of the call loan rate were quite similar across industries, further suggesting that perhaps stocks in most industries were purchased on margin to roughly the same extent.

For the rest of the paper, I analyze prior literature on the subject and commented on what contribution this paper makes to the current literature. The literature highlights an important trend in the view of how important borrowing restrictions are to understanding stock returns. I continue the discussion by describing how I run my empirical tests by outlining the data used and how the regressions were constructed. I then explain my results and conclude by discussing these results and their relevance for future research.

2. Literature Review

The Securities and Exchange Act of 1934 gave the Federal Reserve the authority to set the minimum margin requirement for brokers, dealers, and lenders at the time of purchase.[6] This meant that the margin requirements were no longer market determined and subsequently saw an increase from their 1929 levels.

The crash of 1929 is of particular interest because of the lack of empirical studies done on the effect of changes in call loan rates on daily stock returns. White (1990) discussed the causes of the Great Depression and cited a plethora of reasons behind the crash including Galbraith (1954)'s mania hypothesis, the new economy and the stock

[6] SEC.gov – SEC Act of 1934

market of the 1920s, the role of fundamentals in the bull market of the 1920s, and credit and the stock market boom. Galbraith (1954)'s conventional wisdom focused on the irrationality behind the bubble. He argued that it was a feeling of jubilation among the general public and a view that positive returns would be perpetual which drove up prices.

Both Galbraith (1954) and Kindleberger (1978) hypothesized that the stock market was intrinsically unstable and any one of the factors above could have led to the collapse of public confidence. Fisher (1930) argued that the Smoot Hawley tariff meaningfully contributed to the 1929 demise. Yet White (1990) showed that there is no empirical evidence behind the tariff argument by comparing export reliant indices and import reliant ones. He showed that stocks in these two indices declined by similar amounts after the tariff passed. Finally, Fisher (1930) posited that the failure of Clarence Hatry's financial empire in September of 1929 represented the first main shock to the London stock market which rippled over to the U.S. soon after.

Among the many reasons behind the crash lies the credit and stock market boom hypothesis. Kindleberger (1978) argued that easy credit in the stock market played a large role in creating the mania that led to the bubble and the inevitable bust. Figure 1 shows the growth in loaned funds made by brokers charted against the broad stock market index from 1926 - 1931. It is clear that brokers' loans peaked right before the 1929 crash.

White (1990) pointed out that the easy credit argument during this time period is contradicted by tight monetary policy in the latter half of the 1920s. For example, the Fed implemented contractionary policy in January of 1928 when it increased the discount rate from 3.5 to 5%.[7] Hamilton (1987) argued that this constituted tight money and points out that M1 grew insignificantly in 1929 and the CPI (consumer price index) fell.

The Federal Reserve understood that easy credit gave investors the ability to force security prices up and create instability through speculation. In order to minimize the effect of this, the Federal Reserve Board wanted to prevent member banks from making loans on marginable securities to brokers who eventually made them to consumers. They did this by threatening to close the discount window for member banks if those banks continued to make these loans. The Federal Reserve Bank of New York disagreed with this policy measure and reaffirmed the inability of the Fed to deny discounted assets for member banks. Instead, it proposed raising the discount rate as the only means of curbing speculation. However, a conflict in policy between the Board and the New York Fed prevented rates from rising.

White, Kindleberger, and Fisher all pointed out that easy stock market credit was a key driver in creating the mania that contributed to the market's downfall. However, White (1990) suggested that it is difficult to test for a bubble due to the lack of daily data and improper previous specifications by other authors. This study aims to properly test White (1990) and others' primary hypothesis that it was easy stock market credit that led to the demise in October of 1929 by using call loan rates as a proxy for the cheap borrowing costs that enabled credit-driven speculation. It is apparent that the literature on the subject lacks an empirical study of the changes in daily call loan rates in 1929 and their effect on stock returns. Therefore, the purpose of this paper is to conduct this analysis by not only

[7] Federal Reserve History: Stock Market Crash of 1929

estimating the effect on stock returns to see if these changes in interest rates were a meaningful factor in the crash, but also to estimate the effect of volatility on returns.

In addition to the literature discussed above introducing the topic and the necessity for it, there is an abundance of previous literature on the topic which mostly deals with the effect of margin requirements on volatility. In a seminal paper, Hardouvelis (1990) started by reasoning that the reason the Federal Reserve put into place margin requirements was because it believed that the stock market crash of 1929 was due to credit-financed speculation. As such, reducing the ability to buy on credit should reduce volatility and bring stock returns to their true values. Hardouvelis (1988, 1990) found that stock values were closer to their fundamental values in times when margin requirements were high or were increased than when they were lower or lowered.

Figure 3 shows the relationship between margin requirements and market volatility. The graph shows that there is some correlation between higher official margin requirements and S&P composite volatility. Hardouvelis (1990) performed three tests, one using a monthly measure of volatility, the other a daily, and a Vector Autoregressive (VAR) Analysis. He found that higher margin requirements are linked with future reduced stock return volatility, stock returns, increased trading volume on the New York Stock Exchange (NYSE), and reduced borrowing for stock purchases. Hardouvelis (1990) also found the same results in non-turbulent periods (1934 and onwards).

Hardouvelis (1990)'s reduced form evidence from vector autoregressions showed that while there is a negative relationship between margin requirements and volatility, this does not imply a causation. Furthermore, the opposite relationship implying that volatility is a driver in changing margin requirements is not empirically supported. This is the crux of Schwert (1988b)'s paper which contended that the observed negative relationship between margin requirements and volatility is reflected by the idea that increases in margin requirements seem to come after periods when stock volatility is low and vice-versa. This policy might occur because of the observed relationship that Black (1976) pointed out: when stock prices are high, volatility is typically low. The Fed assumes that high prices are driven by speculation and thus curbing speculation will reduce stock prices to normal levels which brings along higher volatility. Schwert (1988b) concluded that this finding is even more relevant after observing that stock returns behave no differently from normal following a year after the change in margin requirement was implemented. Thus, the conclusion is that the Federal Reserve responds to market conditions and that these actions have no effect on subsequent stock returns.

Hardouvelis (1990) disputed Schwert (1988b) and (Schwert 1989) by pointing out that the inclusion of two very important control variables, the monthly real rate of return of stocks and the growth in the ratio of margin credit to the value of the NYSE, to the general margin requirement - volatility regression leads to the opposite findings of Schwert (1989). Specifically, that there is no relationship between changes in volatility and margin requirement policies but that margin requirement policies do in fact reduce volatility of returns.

Hardouvelis (1989)'s explanation for Schwert (1988b and 1989)'s results is that because high stock returns negatively affect volatility and positively affect margin requirements, the negative volatility - margin requirement relationship is actually due to high stock returns triggering higher margin requirements, not low volatility triggering higher margin requirements and vice versa. I run the opposite test which looks at how volatility effects margin requirements. In short, according to Hardouvelis (1989), low volatility does not drive high margin requirements as Schwert (1989) suggested, but rather the observed negative correlation is actually due to increased stock returns triggering higher margin requirements as a means to bring prices down to their fair values which will increase volatility since prices are lower. Hardouvelis concluded by empirically testing the effects of increased margin requirements on excess volatility and found that excess volatility is higher during periods of low margin requirements. This finding held for post-depression periods as well.

Hardouvelis and Peristiani (1992) contributed to the literature by investigating whether the negative relationship between margin requirements and volatility exists in Japan on the Tokyo Stock Exchange (TSE). The reason this analysis is important is that empirical research in the U.S is constrained due to margin requirements only changing 22 times between 1934 when the SEC gave the Fed the power to change margin requirements and 1992 when Hardouvelis and Peristiani (1992) was written. The Tokyo Stock Exchange (TSE) is particularly useful for this sort of analysis because the exchange has changed the margin requirement over 100 times since Japanese margin regulation was put into place in 1951.[8]

The authors focus on establishing a 24 day investment period for their empirical analysis of the relationship between margin requirements and stock returns. They run a

[8] Tokyo Stock Exchange Fact Book (1989)

regression of returns over the 24 day period on the change in margin requirement preceding this 24 day period. The authors found a statistically significant negative coefficient on the margin rate change variable. The TSE breaks stocks into two sections. This result was found for the first section. In order to determine some measure of causality, the authors performed this analysis on the Second Section of the TSE. The stocks in this Second Section are not allowed to be bought on margin. As such, a causal relationship would imply a stronger effect of margin requirements on marginable securities in the First Section as opposed to the non-marginable ones in the Second.

Hardouvelis and Peristiani (1992) found that while the growth of stock prices in the Second Section of the TSE is negatively related to the change in margin requirements, the correlation between the two variables is materially weaker, implying a stronger foothold for the negative stock price-margin requirement hypothesis. Furthermore, the authors rejected the null that both coefficients on margin requirements between Section One and Section Two are the same, implying that the returns reaction to margin requirements are most definitely different when comparing the two indices. The authors solidified this result by performing the same analysis on a daily frequency, instead a weekly one as done in the prior section. Figure 4 by Hardouvelis and Peristiani (1992) shows the immediate growth in stock prices of the First Section and a far weaker and negative reaction to the Second Section.

Hardouvelis and Peristiani (1992) also tested what relationship margin requirements have on volatility. They found that when a control variable for stock returns is included in the regression, the negative relationship between margin requirements and volatility becomes statistically significant and material.

The next paper which established strong precedent to ignore the findings of Hardouvelis (1988, 1990) was Hsieh and Miller (1990). The authors started by contending that curtailing volatility might not be a good thing because volatility represents the faster incorporation of new information in market prices of securities. They also pointed out that from 1974 to 1990, the Fed had not changed margin requirements because of the view that the impact of these requirements is miniscule.

Specifically, during 1929 and the peak of the boom, total stock market credit did not exceed more than 10% of the market value of traded equities and by 1974, the number dropped to 2%.[9] Hsieh and Miller (1990) tested for the negative relationship between margin requirements and volatility by looking at the 22 historical changes in the requirement and the effects of volatility following these changes. They looked at both short term and long term effects of a policy decision to raise or dampen requirements.

For the short term, the authors looked at whether standard deviation changes from what it was 25 days before the margin requirement change to 25 days after the change. They found very few statistically significant changes in the short term. Specifically, out of the 22 changes in the requirement, only 1 of them showed a statistically significant increase in volatility as margin requirements were decreased which is what we would expect in this sort of specification. The other 2 significant occasions showed that volatility declined when

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[9] Brady Commission Report, Appendix VIII, esp. p. VIII-2

margin requirements declined, a finding that proves counterintuitive to the initial negative requirement - volatility hypothesis.

In the long term, the authors used monthly real returns of the S&P 500 rather than daily returns and the associated standard deviations. They found that across the 22 changes in margin requirements tested, there is a weakly negative relationship between standard deviations and margin requirements but that the Levene statistics do not materially and significantly differ between high margin periods and low margin periods.[10] In explaining their results, which are contradictory to Hardouvelis (1990), Hsieh and Miller (1990) argued that Hardouvelis (1990)'s negative correlation finding is incorrect because of the technical specifications of his model. More specifically. Hardouvelis used the wrong proxy for stock market volatility, implemented an incorrect specification for the time series relationship between margin requirements and volatility, and erroneously set up his multiple regression as it relates to the macroeconomic variables included.

Kupiec (1989)'s analysis of initial margin requirements and stock return volatility also set the precedent for further criticism of Hardouvelis (1988, 1990)'s work. Kupiec's main contribution was the usage of a more appropriate measure of volatility. He used a GARCH in Mean model to estimate daily volatility. Kupiec argued that Hardouvelis' simple measure of a 12 month moving standard deviation is incorrect because it created a misleading correlation between the variables of interest and did not account for the excess kurtosis of stock returns as well as the time dependent conditional variances of auto correlated and moving average components. Furthermore, a GARCH model accounts for

[10] Levene Howard (1960)'s "Levene Statistic" is an inferential statistic used to test the statistical difference between population variances of two or more groups

an equilibrium model of asset returns by relating non diversifiable risk to conditional expected excess of the risk free rate returns.

The primary advantage of the GARCH as it relates to the estimate of volatility is its ability to deal with the non-stationarity of the moments of a distribution. In this case, the relevant 2nd moment, variance as manifested by volatility, moves around and is high in the late 1920s. The results of the GARCH specification show that there exists no statistically significant relationship between margin requirements and excess return volatility. These findings are consistent with Schwert (1988). The other important finding is that the GARCH in Mean specification that Kupiec (1989) ran yielded a 20% less volatile (as measured by standard deviation) data series than the one obtained by Hardouvelis (1988a, 1998b) which used a 12 month moving standard deviation estimate. This result comes from the ability of the GARCH to account for short term spikes and drops in volatility that are exhibited in Hardouvelis' measure of volatility. In my study, I did not try and find a relationship between margin requirements and volatility. Instead, I used volatility as an explanatory variable to explain variation in stock returns. The test that Kupiec (1989) ran to find a relationship between margin requirements and volatility might also be useful in a separate paper given the use of an ARCH model in this paper to estimate volatility.

Finally, Hardouvelis and Theodossious (2002) looked at the effect of margin requirements on volatility in a bull market versus a bear market. Although their result that margin requirements should be increased in bull markets to reduce speculative excess and increased in bear markets to provide liquidity is valuable, the relevance of their paper is to defend the findings of Hardouvelis (1990). Hardouvelis (1990) received criticism from Kupiec (1989), Schwert (1989), Salinger (1989), and Hsieh and Miller (1990) for his incorrect regression specification discussed in Granter-Newbold (1974) regarding the bias in the use of levels and an erroneous measure of monthly volatility. Hardouvelis (2002) started by claiming that the papers only dispute the monthly measure examined in Hardouvelis (1990), not the daily or VAR estimate. Secondly, Hardouvelis (2002) attempted to close the discussion about levels versus differences by showing that the use of levels for margin requirements and not differences is justified because margin requirements and volatility are stationary and thus the specification used to describe the relationship between the two variables does not provide biased results. While this piece of literature isn't directly relevant to the topic of this paper which principally investigates the effect of the change in call loan rates on stock returns, not volatility, this paper is important because it tried to end the debate on the relationship between frequently discussed variables of interest.

Overall, the literature gives mixed findings. The main takeaways are that in the beginning of the study of the topic, the main contributions to the literature were from Hardouvelis who empirically showed a negative margin requirement volatility relationship. Papers after Hardouvelis improved upon his methodology and argued that the regression specifications implemented were flawed and the results differ upon correction of this misspecification.

What is more noteworthy and the subject of the paper going forward is that none of the literature performed any empirical analysis of the interest rate associated with borrowing. Instead, the literature focused on the actual margin requirement itself which as mentioned before, is simply a percentage which indicates how much you can have in cash and how much you can borrow to finance your position in a security. In 1929, the margin requirements and the call loan rates were market determined. These call loan rates are borrowing costs and while there isn't a definite downward trend in 1929 for call loan rates, call loan rates were generally much lower in the second half of 1929 during the buildup to the bubble and the subsequent crash.

The purpose of this paper as mentioned before is to determine what impact, if any, these low borrowing costs had on the run up of prices and subsequent crash of 1929 when accounting for daily volatility. The following sections outline the collection of data, the specification itself, and the results of an empirical analysis missing in the existing literature.

3. Data

The difficulty in this analysis lies in the relative scarcity of the data required to perform an empirical analysis. This is one possible explanation reason for why previous studies have not conducted this analysis. With the exception of Fohlin (2017), there is no literature documenting the daily call loan rates in 1929. As such, I used the historical New York Times (NYT) in the ProQuest database to manually collect daily call loan rates in 1929. The last close was used for empirical purposes although ProQuest has information on data from the year prior as well as the day prior. I then filtered out weekends and holidays. In addition, because some NYT excerpts are incompletely scanned, missing values in the data were replaced by linear interpolations of the preceding and subsequent data points.

After collecting this information, I collected daily total stock returns, SMB and HML Fama-French factor returns, and data on the risk free rate during 1929. I filtered out the trading days on Saturday to align the data with the call loan. During this time, stock markets traded on Saturday but call loan rates were not. In addition to total stock market data, I also collected data on 12 industries. Industries include non-durables, durables, manufacturing, energy, chemicals, business equipment, telecommunications, utilities, shops, healthcare, money and other. They act as a portfolio of different securities within these twelve categories.

The data used in my model comes both from the Ken French website and the Wharton Research Data Services (WRDS).

4. Empirical Analysis

The goal of this paper is to determine whether the change in call loan rates affects stock returns. Specifically, did the relatively low cost of borrowing prop up the market and create a bubble which was inevitably going to burst? What about volatility? Do we find a negative relationship between volatility and stock prices? Do increases in call loan rates quell high stock returns when accounting for volatility? How does this result vary across industries? These are the questions that I aim to answer by running regressions on the market in addition to 12 industries to determine what effect a change in call loan rates has on stock returns.

The primary result is how call loan rates affect the total stock market. I used the *mktrf* variable which denotes the total daily stock market return less the daily risk free return. On the right hand side of the regression is alpha, the percentage change in daily call loan rates, and percentage change in daily volatility.

Arriving at a precise measure of volatility was important to avoid the criticism discussed above that Kupiec (1989) made of Hardouvelis's (1988) paper which used a 12 month moving average of standard deviation of returns. Volatility is a statistical measure of security price fluctuations within a given time period and is represented as the square of the daily return series. The daily volatility is the measure of fluctuations within a day and is calculated as the one period lag difference squared of a return series.

Overview of the GARCH and ARCH

Engle (1982) developed the ARCH model while Bollerslev (1986) created the GARCH model. Both argued that these models were designed to deal with the assumption of non-stationarity in financial data. Miah and Rahman (2016) highlight that ARCH and GARCH models have become important tools for dealing with time series heteroscedasticity by treating heteroscedasticity as a variance to be modelled. The goal of such models is to provide a volatility measure like a standard deviation that does not remain constant and that can be used in financial decisions.

Aktan, Korsakienė, and Smaliukiene (2011) pointed out that the magnitude of the estimated parameters α and β describes the short-run characteristics of the resulting volatility time series. Large GARCH lag coefficients (β) indicate that volatility is persistent because shocks to conditional variance take a long time to die out. Large GARCH error coefficients (α) indicate that volatility reacts strongly to market movements, and if (α) is relatively high and (β) is relatively low, volatilities spike frequently in the period of interest. To get a benchmark for what is large, Alexander (2001) shows that in financial markets it is common to estimate (β) lag coefficients based on daily observations in excess of 0.8 and (α) error coefficients of no more than 0.2.

I use the ARCH lagged by 1 day which was derived by Engle (1982). I did not use Bollerslev (1986) GARCH model due to the inability for the GARCH to fit market data for 1929. The GARCH specification is outlined below. The ARCH ignores the last term of the GARCH specification which uses previous period volatility as an input for future volatility forecasts.

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \quad (1)$$

Miah and Rahman (2016) described the above specification and terms as the following: σ_t^2 is the conditional variance of returns, ω, α_i and β_j are coefficients that need to be estimated through this specification, and ε_{t-i}^2 is the residual lagged returns by whatever specification is chosen. σ_{t-j}^2 is the lagged variance. Miah and Rahman (2016) explained that a primary challenge in financial modelling is to find the right model from a family of models that best fits the data. The most common criteria in determining whether a candidate model is too simple or unnecessarily complex are the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC).

AIC: T x ln(residual sum of squares – (RSS)) + 2n

BIC: T x ln(RSS) + nln(T)

T is the number of observations and n is an estimated parameter. In an analysis of 4 Bangladeshi companies, Miah and Rahman (2016) found that a (1,1) specification of the

GARCH(p,q) is the best fit for their data. Optimally, an AIK and BIC analysis would be done for the market data. However, given the inability for the GARCH to fit the model in addition to an ARCH (1) yielding statistically significant coefficients for 1929, an ARCH (1) was used to forecast volatility. The ARCH specification is therefore just the GARCH minus the last term. The ARCH model yields a variance. As such, the square root is taken to arrive at standard deviation. Then the value from the previous day is subtracted from today's value to obtain a difference which then is expressed as a percentage. This final variable form is used for the regression.

In addition to call loan rates and volatility, the SMB and HML factors from Fama and French (1993) were included. Eugene Fama and Ken French developed a model to describe and explain variation in stock returns. They found that there are three main factors which are able to explain roughly 90% of diversified portfolio returns. The first factor is the market returns, the second is "SMB" or small-minus-big. This refers to the observed outperformance of smaller company stocks over bigger stocks. The third main factor is "HML" or the outperformance of companies with high book to market values over those that have lower book to market values. This model is an expansion of the traditional capital asset pricing model (CAPM) which uses only market risk to describe returns and describes about 70% of the returns variation. Building upon the CAPM, Fama and French arrived at the following specification:

(2) $$R_m - R_f = \alpha + \beta_1 x \left(R_m - R_f\right) + \beta_2 \, x \, SMB + \beta_3 \, x \, HML + \varepsilon$$

The Fama-French specification is relevant for this paper because it provides a baseline of important variables to include to explain variation. The final two regression specifications run on the market are below:

(3) $R_m - R_f = \alpha + \beta_1 x \ (caldiffpct) + \varepsilon$

(4) $R_m - R_f = \alpha + \beta_1 x \ (caldiffpct) + \beta_2 x \ (volldiffpctmkt) + \varepsilon$

In addition, the regression specifications for each industry are adapted by changing the left hand to the relevant industry less the risk free rate but retaining the market measure of volatility. The industry specific regressions are below:

(5) $R_{Industry,i} - R_f = \alpha + \beta_1 x \ (R_m - R_{f)} + \beta_2 x \ (caldiffpct) + \varepsilon$

(6) $R_{Industry,i} - R_f = \alpha + \beta_1 x \ (caldiffpct) + \beta_2 x \left(volldiffpctmkt_{industry,i}\right) + \varepsilon$

(7) $R_{Industry,i} - R_f = \alpha + \beta_1 x \ (R_m - R_{f)} + \beta_2 x \ (caldiffpct) + \beta_3 x \ SMB +$
$\beta_4 x \ HML + \varepsilon$

(8) $R_{Industry,i} - R_f = \alpha + \beta_1 x \ (R_m - R_{f)} + \beta_2 x \ (caldiffpct) +$
$\beta_2 x \ (volldiffpctmkt) + \beta_3 x \ SMB + \beta_4 x \ HML + \varepsilon$

After establishing the regression specification, STATA was used to carry out the analysis. Data was created in a CSV and imported into STATA. The results are discussed below.

5. Results

Table 1 highlights the major results from this study. The first two regressions (3), (4) which are the main results of this paper look at the change in call loan rates on excess market returns in 1929. The second version of this regression includes the measure of volatility. I found that the coefficient on calldiffpct, the variable which describes the daily percentage change on call loan rates, to be -1.653 without the inclusion of volatility and -1.609 upon the introduction of volatility into the regression. All three coefficients are statistically significant with the two coefficients on the call loan rate being significant at the 5% level while the one on volatility at the 1% level. Therefore, a one standard deviation move in the call loan rate of 0.18% implies a 0.30% drop in daily stock returns. After including volatility, this drop in stock returns becomes 0.29%. This shows that a part of the drop in stock returns in attributable to volatility but not much. A one standard deviation change in daily volatility of 0.60% reduces daily stock returns by 0.37%. This confirms Black (1976)'s finding that volatility and stock returns are inversely related. The adjusted R^2 is low at 1.4% without volatility and 3.9% with volatility. Although this is not technically a margin requirement in the traditional sense, the call loan rate implies a constraint on borrowing which when increased, reduces stock market returns.

The next specification run (5) was excess industry returns on excess market returns and the call loan rate variable. I found that the only industry with a significant coefficient was manufacturing with a value of -0.449 with significance at the 5% level. A one standard deviation move of 0.18% in call loan rates implies a 0.08% move in daily manufacturing returns. After including volatility in the specification (6), manufacturing is the only industry that remains statistically significant and negative when observing the effect of call loan rates on returns. Manufacturing, business equipment, shops, health, money and other all had statistically significant coefficients on the volatility variable. Shops, health, money, and other all had negative coefficients on volatility while manufacturing and business equipment had positive relationships with volatility.

Regression specification (7) looks at the effect on excess industry returns from the excess market returns, call loan rates, and SMB and HML. Upon the inclusion of the Fama-French factors, manufacturing returns and call loan rates exhibited a negative association while call loan rates and health exhibited a positive relationship. Both relationships were statistically significant with a coefficient on call loan rates for manufacturing of -0.400 and 0.889 for health. This implies that a one standard deviation move in call loan rates implies a reduction in daily manufacturing stock returns of 0.072% and a 0.16% increase in daily health stock returns.

Finally, in regression specification (8), I looked at the effect of excess market returns, call loan rates, volatility, SMB, and HML on industry stock returns. I found that manufacturing has a -0.362 coefficient on the call loan rate variable and a 0.253 coefficient on the volatility variable. The call loan rate was statistically significant at the 5% level and the volatility at the 1% level. Money also had a statistically significant result on volatility with a coefficient of -0.229 at the 5% level.

In order to understand why these results might persist both on the returns and volatility side, a potential approach might look at trading volumes on margin for specific industries to see if these industries that had statistically significant results were also industries that had high margin trading volume. This might lead to a better understanding of which industries are more sensitive to higher interest rates.

Furthermore, it is reasonable to have found that not all industries exhibit a negative relationship between call loan rates and stock returns or volatility and stock returns. Average cumulative alpha of all industries must sum to roughly 1 since those industries make up the total market. Thus, some industries are bound to do better than others and worse than others. In addition, their sensitivity to call loan rates varies based on the proportion of trades placed on margin for that industry. This explanation extends to volatility in that on average, the market falls with increases in volatility, but some industries fall less than others and this result changes depending on what time horizon is observed.

What is noteworthy is that results for industries show that manufacturing tends to be consistently sensitive to changes in margin requirements which would imply that manufacturing stocks might be bought more on margin than chemicals for example. Overall, the main result of interest falls in line with the hypothesis that increases in call loan rates reduce stock returns in 1929 when controlling for the relevant variables.

6. Discussion and Conclusion

White (1990) aptly pointed out the real possibility that low call loan rates could have been responsible for the Great Depression and crash that is so frequently written about. However, before and after White's paper, others in the literature have focused mainly on the effect of a margin requirement on stock returns and volatility. Hardouvelis initially posited that margin requirements are reactionary measures which the Fed uses to curtail volatility and temper inflated stock returns. However, authors after him such as Hsieh and Miller (1990) pointed out the flaws in his test design and showed that margin requirement changes follow changes in stock prices rather than lead them. They also showed that there is no statistically significant change in stock prices when the Federal Reserve changes the margin requirement.

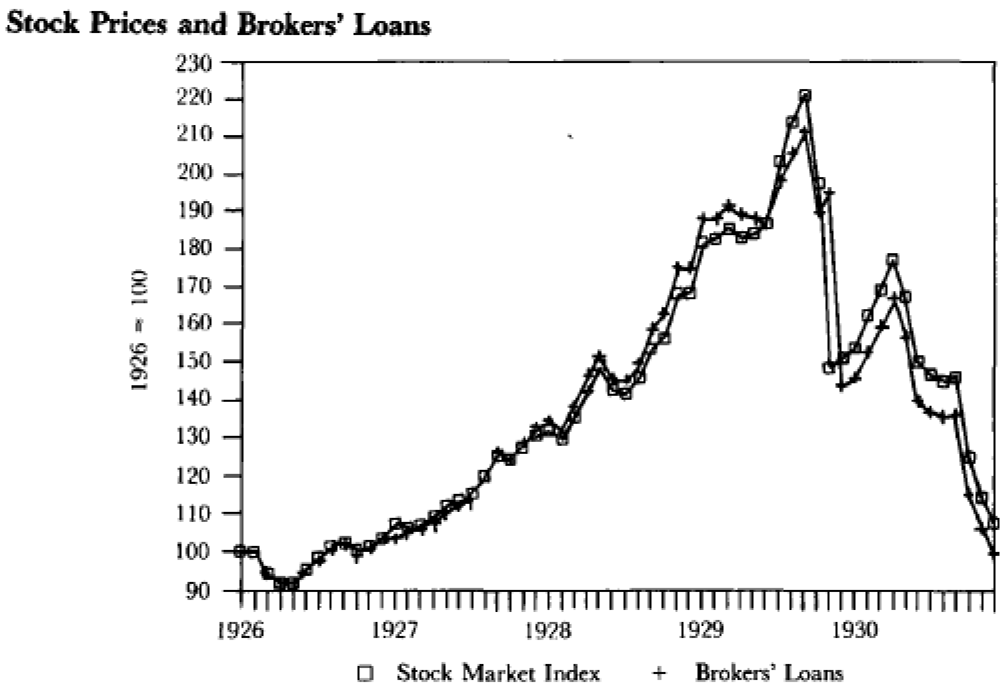
While the existing literature is important for the impact of holding little cash to finance a large position, it does not speak to the impact of having a low cost of borrowing. The purpose of this paper was to investigate this issue, specifically in 1929 when the call loan rate was not set by the Federal Reserve. This has interesting implications because the rate was significantly lower during this time partially because it was market determined. What impact did this have on overall returns? According to the empirical analysis presented in this paper, the low rates contributed meaningfully to the inflated prices that eventually resulted in the October crash. This is accounting for volatility which is also shown to be negatively correlated with returns.

However, this result did not hold for most industries. Does this mean that one can avoid the negative impacts of a potential change in call loan rates by just investing in specific industries? Perhaps. But in 1929, this was tough considering the large drop in the entire stock market. What does this trend say about potential trading strategies, a future topic to be investigated in relation to this paper? One could conceivably create options on potential reactions in the market to changes in call loan rates by going long on industries that are less affected by call loan rates and go short the ones that are more affected (manufacturing, healthcare, or even the entire market). Or in a more general sense, can one make bets about how the market will do if they for see a change in Federal Reserve policy on the horizon? According to previous papers on this subject, none of these anomalies should exist when looking at a strict change in margin requirements. But it is unclear what happens in regards to changes in the call loan rate.

A completely separate paper replicating the studies of previous papers which looked at the 23 changes in margin requirements since the Fed was given that ability until the time of the paper being published could be replicated for large changes in call loan rates. Furthermore, this study could be replicated for different periods to see if the result still persists. This result as of now is specific to just 1929 because of the unique nature of how the rate was set, how low it was relative to today, and the obvious crash in October. This study could be a valuable tool in driving Federal Reserve policy for the future and shape the way that investors think about trading on margin.

7. Appendix

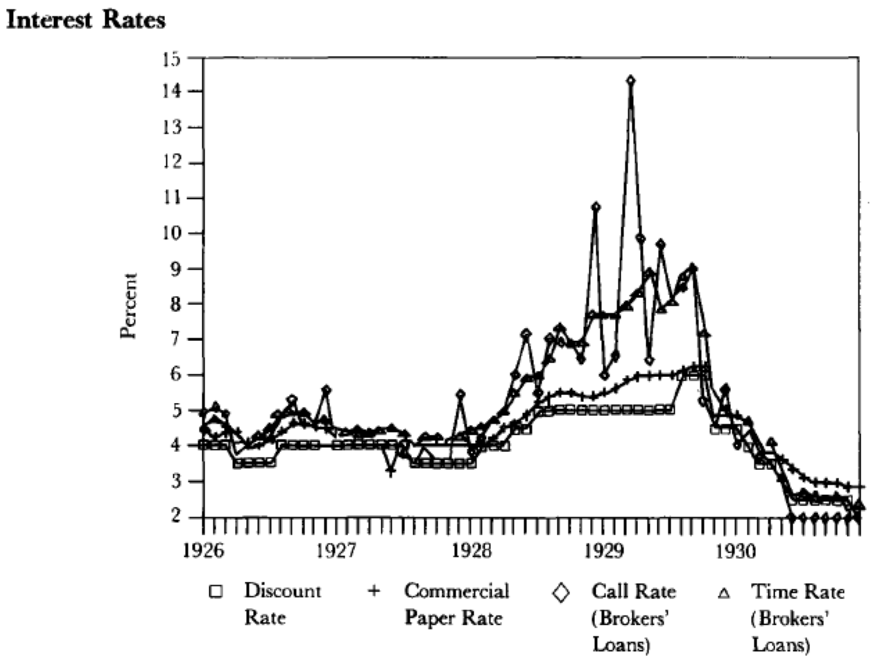
Figure 1: Stock Prices and Broker Loans from 1926 – 1931[11]



Source: Board of Governors of the Federal Reserve system (1943) and the New York Stock Exchange *Year Book* (1931).

[11] Figure taken from White (1990) paper. Data not readily available for chart recreation.

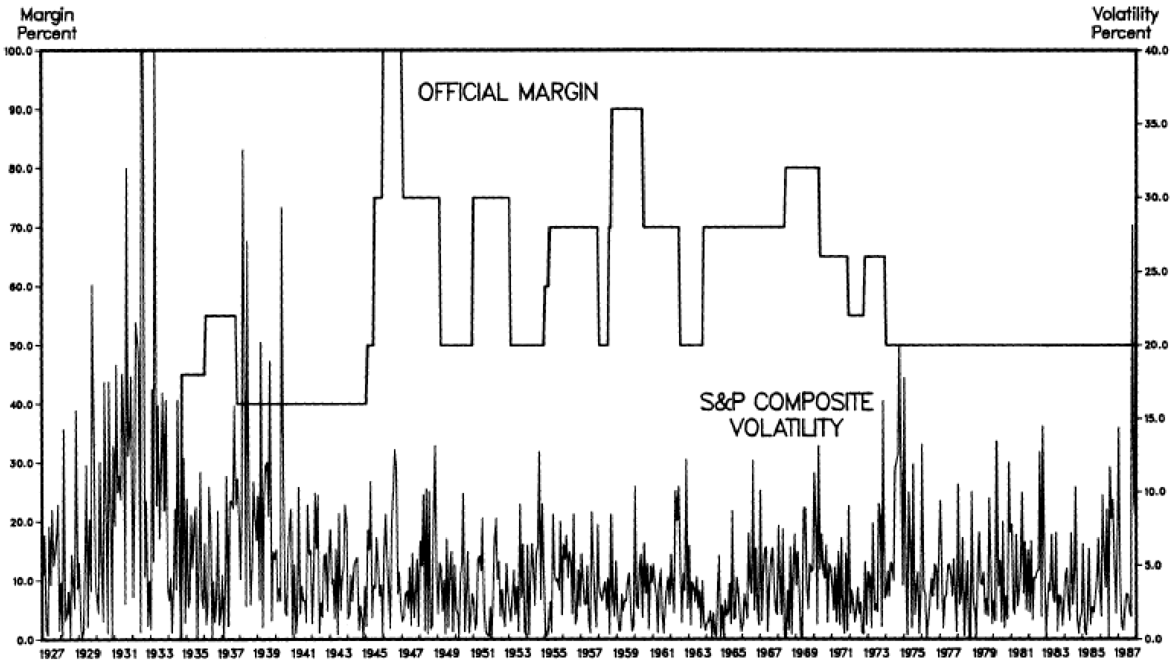
Figure 2: Interest Rates from 1926 – 1931 [12]



Source: Board of Governors of the Federal Reserve System (1943).

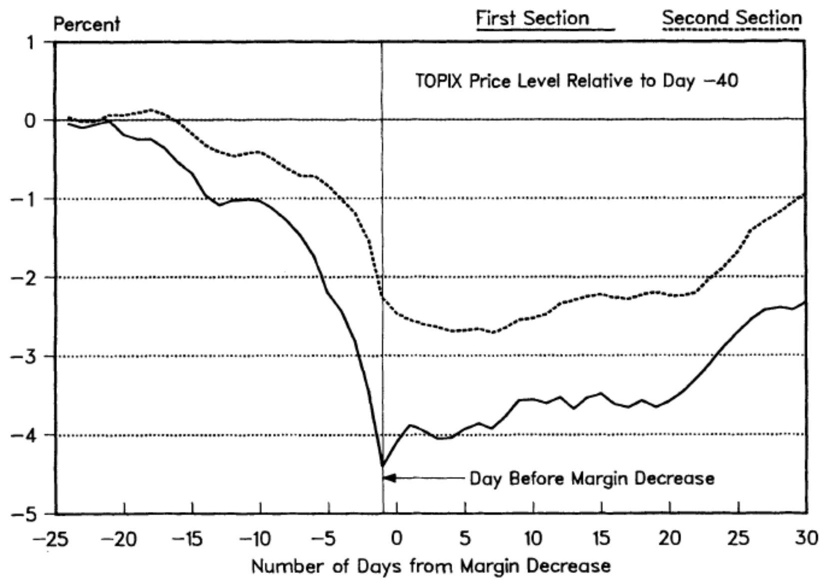
[12] Figure taken from White (1990) paper. Data not readily available for chart recreation.

Figure 3: Official Margin Requirements vs. S&P Composite Volatility [13]



[13] Graph taken from Hardouvelis (1990). Data not readily available for recreation.

Figure 4: Margin Decrease vs. Stock Price Reaction [14]



[14] Taken from Hardouvelis and Peristiani (1992). Data not readily available for graph reconstruction.

Figure 5: Call Loan Rates in 1929

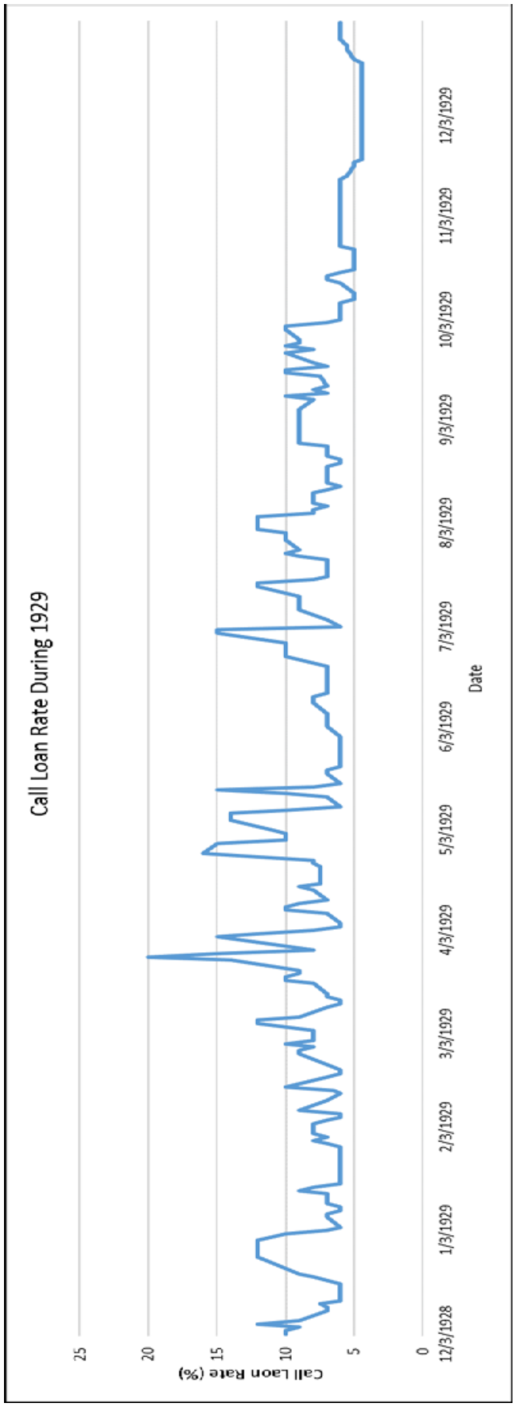


Table 2: Call Loan Rate Changes on Market and Industry Returns

Following econometric specifications (2) through (7), in this Table I show primarily the estimated effects of the change in daily call loan rates in percent on market excess returns. I control for market excess returns, daily volatility as measured by an ARCH (1), the Fama-French SMB and HMl factors for explaining returns, and alpha. Security market data was hand collected at a daily frequency from Ken French's website and CRSP. Security returns are value weighted historical returns of all stocks listed on the NYSE, AMEX, or NASDAQ for which complete data exists. Daily call loan rate data was found in the historical *New York Times* on the ProQuest database from January 1929 - December 1929. An ARCH (1) model was estimated using daily returns on excess market returns in 1929 and used to calculate daily volatility. Columns 1 and 2 indicate excess market returns as the dependent variable, while columns 2-49 are excess industry returns used for the six specifications mentioned earlier in the paper. The independent variables are listed on the left hand horizontal axis. Excess market returns are only used as a control in industry specific regressions. P-values: *10%, ** 5%, ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable:	Mkt-Rf	Mkt-Rf	Non-Durables - Rf	Durables - Rf	Manufacturing - Rf	Energy - Rf	Chemicals - Rf	Business Equipment - Rf
Market - Rf			0.756***	1.191***	0.961***	0.826***	1.313***	1.383***
			(0.014)	(0.035)	(0.015)	(0.029)	(0.028)	(0.030)
Call Loan Rate Difference in	-1.654**	-1.610**	-0.092	0.222	-0.450**	-0.197	0.378	-0.411
	(0.759)	(0.749)	(0.177)	(0.426)	(0.178)	(0.346)	(0.343)	(0.366)
Volatility Difference in		-0.614***						
		(0.226)						
SMB								
HML								
Alpha	-0.059	0.001	-0.017	-0.148	.0195	-0.006	0.131	0.172**
	(0.137)	(0.137)	(0.031)	(0.076)	(0.032)	(0.062)	(0.061)**	(0.065)
Adjusted R^2	0.014	0.039	0.915	0.822	0.946	0.773	0.896	0.894

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Dependent Variable:	Telecom - Rf	Utilities - Rf	Shops - Rf	Health - Rf	Money - Rf	Other - Rf	Non-Durables - Rf	Durables - Rf
Market - Rf	0.866***	1.268***	0.952***	0.843***	1.366***	0.651***	0.751***	1.190***
	(0.033)	(0.029)	(0.022)	(0.032)	(0.026)	(0.168)	(.014)	(0.036)
Call Loan Rate Difference in %	0.043	0.286	0.008	0.548	0.432	-0.094	-0.092	0.222
	(0.401)	(0.344)	(0.271)	(0.393)	(0.314)	(0.203)	(0.176)	(0.426)
Volatility Difference in %							0.104	0.053
							(0.053)	(0.129)
SMB								
HML								
Alpha	0.094	0.163***	-0.125**	-0.016	-0.010	0.0175	-0.007	-0.153**
	(0.072)	(0.062)	(0.049)	(0.071)	(0.056)	(0.0364)	(0.032)	(0.077)
Adjusted R^2	0.733	0.889	0.880	0.729	0.918	0.860	0.916	0.821

	(17)	(18)	(19)	(20)	(21)	(21)	(22)	(23)
Dependent Variable:	Manufacturing - Rf	Energy - Rf	Chemicals - Rf	Business Equipment - Rf	Telecom - Rf	Utilities - Rf	Shops - Rf	Health - Rf
Market - Rf	0.971***	0.825***	1.310***	1.395***	0.875***	1.274***	0.942***	0.819***
	(0.014)	(0.029)	(0.029)	(0.030)	(0.033)	(0.028)	(0.022)	(0.031)
Call Loan Rate Difference in %	-0.448***	-0.197	0.377	0.412	0.434	0.286	0.006	0.544
	(0.172)	(0.346)	(0.344)	(0.363)	(0.399)	(0.343)	(0.267)	(0.379)
Volatility Difference in %	0.213***	0.001	-0.063	0.252**	0.195*	0.115	-0.216	-0.508***
	(0.052)	(0.105)	(0.104)	(0.110)	(0.121)	(0.104)	(0.081)	(0.115)
SMB								
HML								
Constant	-0.001	-0.006	0.137	0.147**	0.075	0.152**	-0.104	0.032
	(0.031)	(0.063)	(0.063)	(0.065)	(0.0726)	(0.062)	(0.048)	(0.068)
Adjusted R^2	0.737	0.772	0.895	0.895	0.734	0.889	0.884	0.751

	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)
Dependent Variable:	Money - Rf	Other - Rf	Non-Durables - Rf	Durables - Rf	Manufacturing - Rf	Energy - Rf	Chemicals - Rf	Business Equipment - Rf
Market - Rf	1.349***	0.645***	.7839***	1.091***	.982***	.965***	1.222***	1.215***
	(0.025)	(0.016)	(0.019)	(0.048)	(0.020)	(0.038)	(0.039)	(0.039)
Call Loan Rate Difference in %	0.430	-0.095	-.002	-0.030	-0.400**	0.136	0.155	-0.018
	(0.306)	(0.201)	(0.166)	(0.426)	(0.181)	(0.336)	(0.344)	(0.341)
Volatility Difference in %	-0.338***	-0.129**						
	(0.092)	(0.061)						
SMB			0.225***	-0.238	0.007	0.152**	-0.140**	-0.427***
			(0.034)	(0.087)	(0.037)	(0.068)	(0.070)	(0.069)
HML			-0.050	-0.301***	0.103*	0.579***	-0.345***	-0.491***
			(0.059)	(0.151)	(0.064)	(0.119)	(0.122)	(0.121)
Constant	0.021	0.029	0.018	-0.182**	0.019	.010	0.113*	0.110
	(0.055)	(0.036)	(0.029)	(0.076)	(0.032)	(0.060)	(0.061)	(0.061)
Adjusted R^2	0.923	0.862	0.928	0.828	0.946	0.794	0.899	0.911

	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)
Dependent Variable:	Telecom - Rf	Utilities - Rf	Shops - Rf	Health - Rf	Money - Rf	Other - Rf	Non-Durables - Rf	Durables - Rf
Market - Rf	0.728***	1.151***	1.002***	0.959***	1.374***	0.754***	0.786***	1.082***
	(0.041)	(0.038)	(0.027)	(0.959)	(0.035)	(0.021)	(0.019)	(0.050)
Call Loan Rate Difference in %	0.047	0.007	0.171	0.889**	0.481*	0.162	0.000	-0.043
	(0.358)	(0.339)	(0.238)	(0.356)	(0.307)	(0.163)	(0.166)	(0.427)
Volatility Difference in %							0.021	-0.089
							(0.053)	(0.136)
SMB	-0.636***	-0.128*	0.437***	0.601***	0.261***	0.201***	0.230***	-0.261**
	(0.073)	(0.069)	(0.048)	(0.072)	(0.062)	(0.038)	(0.036)	(0.094)
HML	-0.158	-0.483***	-0.118	0.077	-0.179*	0.352***	-0.049	-0.305**
	(0.127)	(0.120)	(0.084)	(0.126)	(0.109)	(0.067)	(0.059)	(0.152)
Constant	-0.004	0.148**	-0.054	0.077	0.032	0.045	0.017	0.177**
	(0.064)	(0.060)	(0.042)	(0.063)	(0.055)	(0.033)	(0.029)	(0.076)
Adjusted R^2	0.794	0.896	0.910	0.786	0.924	0.883	0.928	0.828

	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)
Dependent Variable:	Manufacturing - Rf	Energy - Rf	Chemicals - Rf	Business Equipment - Rf	Telecom - Rf	Utilities - Rf	Shops - Rf	Health - Rf
Market - Rf	1.007***	0.975***	1.206***	1.217***	0.710***	1.157***	1.005***	0.938***
	(0.020)	(0.040)	(0.040)	(0.040)	(0.042)	(0.040)	(0.028)	(0.042)
Call Loan Rate Difference in %	-0.361**	0.151	0.130	-0.015	0.021	0.015	0.174	0.847**
	(0.174)	(0.336)	(0.344)	(0.342)	(0.358)	(0.340)	(0.239)	(0.354)
Volatility Difference in %	0.252***	0.098	-0.162	0.023	-0.174	0.052	0.023	-0.211*
	(0.055)	(0.107)	(0.110)	(0.109)	(0.114)	(0.109)	(0.076)	(0.113)
SMB	0.072*	0.178**	-0.181	-0.421***	-0.680***	-0.115	0.443	0.547***
	(0.038)	(0.074)	(0.075)	(0.075)	(0.078)	(0.074)	(0.052)	(0.078)
HML	0.114*	0.583***	-0.352	-0.490***	-0.166	-0.481***	-0.117	0.068
	(0.062)	(0.119)	(0.122)	(0.121)	(0.127)	(0.121)	(0.085)	(0.126)
Constant	0.005	-0 .005	0.122	0.108*	0.005	0.145**	-0.056	0.089
	(0.031)	(0.060)	(0.061)	(0.061)	(0.064)	(0.061)	(0.043)	(0.063)
Adjusted R^2	0.950	0.793	0.900	0.910	0.795	0.896	0.910	0.788

	(48)	(49)
Dependent Variable:	Money - Rf	Other - Rf
Market - Rf	1.351***	0.752***
	(0.036)	(0.022)
Call Loan Rate Difference in %	0.446	0.158
	(0.305)	(0.189)
Volatility Difference in %	-0.229**	-0.023
	(0.097)	(0.060)
SMB	0.202***	0.195***
	(0.067)	(0.041)
HML	-0.189*	0.351***
	(0.108)	(0.067)
Constant	0.045	0.046
	(0.054)	(0.034)
Adjusted R^2	0.925	0.882

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